KA-BAND DOWN CONVERTER AND UP CONVERTER IN MCM-C TECHNOLOGY FOR FUTURE TELECOMMUNICATION EQUIPMENT

Agnès RECLY, Christian TRONCHE, Jean-Louis CAZAUX, Jean-Bernard DUCROCQ

ALCATEL SPACE INDUSTRIES, 26 Avenue J.F.Champollion, 31037 TOULOUSE, FRANCE
Tel: 33 (0)5 34 35 57 60; Fax: 33 (0)5 34 35 69 47

***Abstract* — Over recent years, the miniaturization of R.F. and L.F. functions and the developments were running around the MCM technology.**

This paper presents the work made, then the results, to get new MCM-C generic components for use as building blocks in future Ka-Band equipment.

The results show an actual reduction of weight and volume in comparison with the already advanced design made from separate micro-packages and a multi-layer polyimide PCB for the low frequency part. This is achieved at equivalent electrical performances.

A full description of the products is detailed hereafter.

I. INTRODUCTION

Multimedia networks continue to be implemented world-wide, and the capacity of these networks is rapidly increasing. Satellites will play a major role in the development of the Global Information Infrastructure, completing the substantial investments being made for terrestrial networks. Several ambitious programs for multimedia application are announced like Cyberstar, Teledesic, Euroskyway, Spaceway,.... Low cost, high production rate, high complexity space hardware for satellite constellations are the main drivers for the satellite industry.

These projects must emphasize the dual effort in developing hardware with suitable risk and low cost fabrication, as well as enhancing the performance of the electronics.

In view of addressing the Ka-Band market Alcatel Space Industries has developed, with the support of European Space Agency, generic components for use as building blocks in future equipment which can be proposed on different Ka-Band telecommunication satellite programs.

In this study, named "Components for Ka-Band Telecommunication Equipment", Alcatel has realized a demonstrator at breadboard level of a Ka/C Band Down Converter and a C/Ka Band Up Converter. These building blocks are presented in this paper.

II. PAYLOAD ARCHITECTURE

From the satellite system needs, two main types of payload architectures can be envisaged : a transparent or a regenerative repeater. For instance, a payload with two intermediate frequencies compatible with analog IF switching and digital baseband switching is shown in figure 14. Only the parts 30 GHz/IF1 Down Converter and IF1/20 GHz are considered here.

III. NEW TECHNOLOGY

In order to achieve all functions in a modular way and to reduce size, weight and cost, Alcatel has chosen the use of the MCM-C technology.This technology is the natural extension of our current technology (hermetic micro-packages with ceramic feedthrough) currently proposed for commercial space equipment [1].

MCM-C is a multi-layer substrate based on aluminium oxide. The lines and vias are printed on the different layers then all the layers are cofired at high temperature (HTCC - High Temperature Cofired Ceramic). Wherever required, metal parts such as lead-frames, heat sinks and/or seal rings could be soldered with a silver-copper eutectic. Then, all exposed surfaces are plated. On both sides of the final substrate, components could be bonded inside or outside hermetic areas.

In comparison with a solution based on micro-packages, the main advantages are :

- direct connection to the power supply and commands through the multi-layer substrate,
- less RF connections,
- reusing of the well known ceramic feedthroughs optimized for Ka-Band with their electrical performances.

This MCM-C technology is going to fly on Ku-Band equipment for Stentor, a French technological satellite.

IV. BUILDINGS BLOCKS

A new generation of compact products is developed through these two Buildings Blocks : Ka/C Band Down Converter and C/Ka Band Up Converter [2]. They are realized using MCM-C technology which allows a mass reduction of about 30% compared to the existing MMIC plus micro-package generation.

At the present time, three MCM-C substrates have been designed and manufactured : a Down Converter, an Up Converter and an Amplifier. The two first substrates have been studied for accommodating both sub-systems, including RF, IF and multiplier sections (with an external LO). The third one can be used for several frequency bands (C-Band, Ka-Band, ...), with the possibility to have temperature compensation and gain control.

The design of these substrates have been conducted in order to be compatible with the majority of the Alcatel MMICs chipsets and a large number of commercial MMICs. Several configurations can be realized with the same MCM in order to have the right answer to every program.

The MCM have been populated. First testing results are very successful.

A. Down Converter

The block diagram of this MCM is given in figure 1.

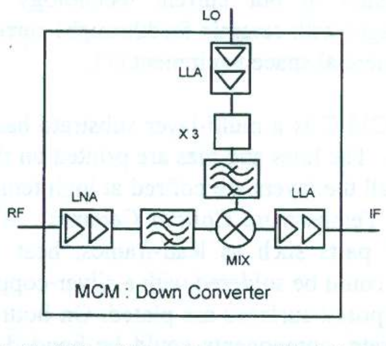

Figure 1 : Ka/C Band Down Converter block diagram

The MCM has only components on the top side. The back side is a ground.

The top side (figure 2) has two main parts :

- the R.F. multi-cavities with all the MMICs, bounded with a proprietary process developed by Alcatel,
- the bias passive components directly soldered, using a standard process.

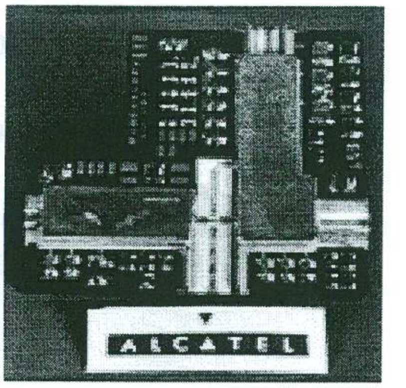

Figure 2 : Ka/C Band Down Converter MCM

This MCM has entirely been tested in a separate test yig with a PCB board to tune the bias voltages of each chip.

All specified performances have been carried out. A gain around 20 dB (figure 3, with an 20 dB attenuation for the measurements) and a noise figure less than 7 dB (figure 4) are achieved. Several modules have been tested to guaranty the reproducibility of this technology.

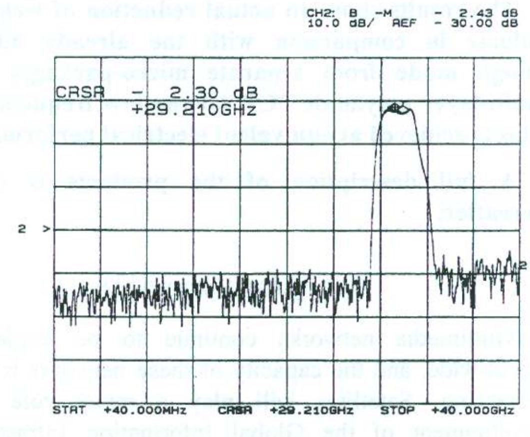

Figure 3 : Gain of the Down Converter

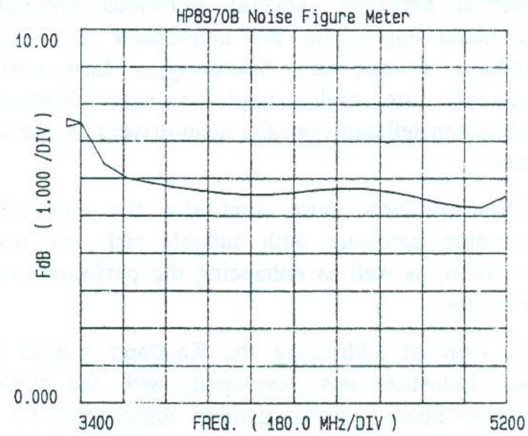

Figure 4 : Noise Figure of the Down Converter

The DC consumption of this MCM is close to 850 mW.

B. Up Converter

The block diagram of this MCM is given in figure 5.

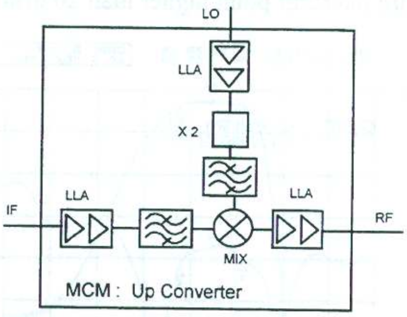

Figure 5 : C/Ka Band Up Converter block diagram

As the first one, this MCM has only components on the top side.

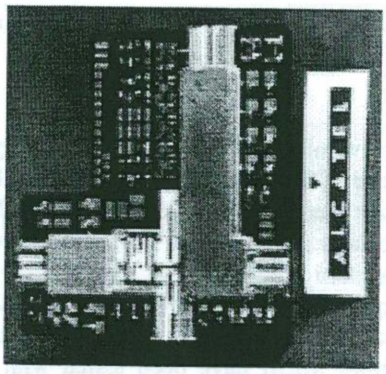

Figure 6 : C/Ka Band Up Converter MCM

This MCM has been entirely tested in a separate test yig with a PCB board to tune the bias voltages of each chip.

All specified performances have been carried out. A gain around 15 dB (figure 7) and a noise figure less than 7 dB (figure 8) are achieved. Several modules have also been tested to guaranty the reproducibility of this technology.

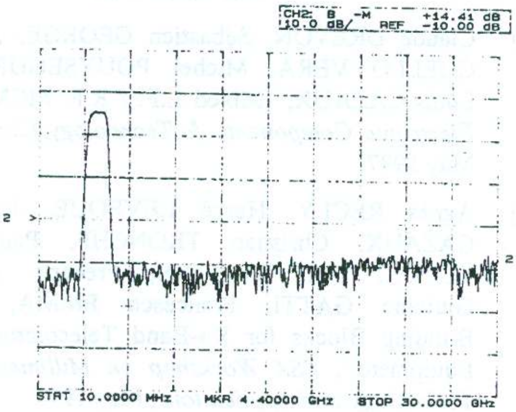

Figure 7 : Gain of the Up Converter

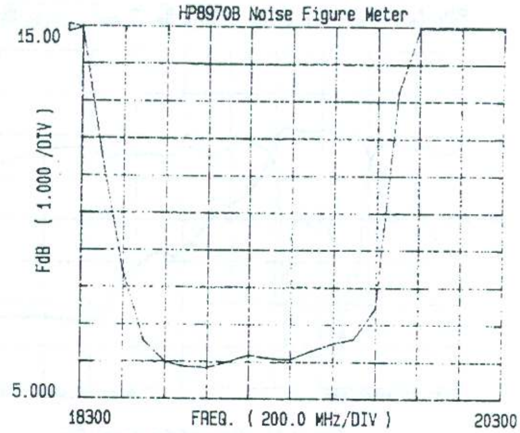

Figure 8 : Noise Figure of the Up Converter

The DC consumption of this MCM is close to 750 mW.

C. Amplifier

The block diagram of this MCM, in Ka-Band configuration used in the complete Down Converter, is given in figure 9. C-Band configuration is also possible in the frame of the complete Up Converter.

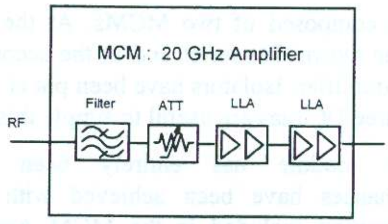

Figure 9 : Ka-Band Amplifier block diagram

As the previous ones, this MCM has only components on the top side.

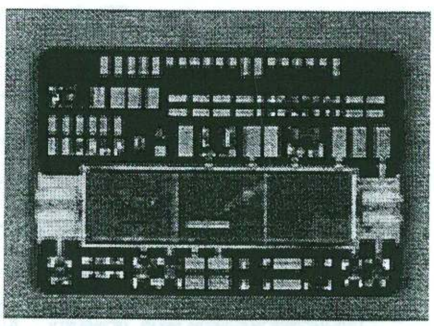

Figure 10 : Ka-Band Amplifier MCM

This MCM has been entirely tested in a separate test yig with a PCB board to tune the bias voltages of each chip.

All specified performances have been achieved. A gain around 20 dB (figure 11) is carried out, with a wide dynamic range used for temperature compensation. Several modules have also been tested in C-Band and Ka-Band to guaranty the reproducibility of this technology.

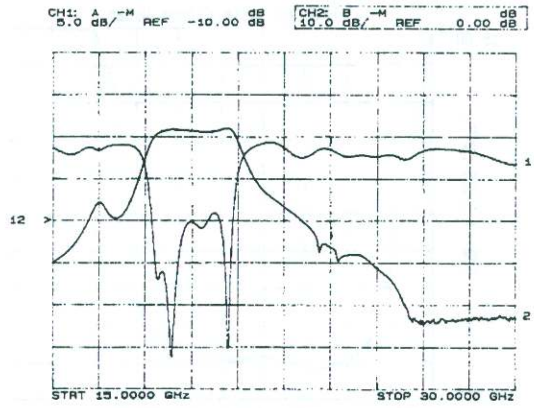

Figure 11 : Gain of the Amplifier

The DC consumption of this MCM is close to 600 mW.

V. COMPLETE MODULES

Each MCM has firstly been tested. Then both are assembled together in a same structure for final tests. These modules are described hereafter.

A. Down Converter Module

It is composed of two MCMs. At the first stage, we have the Down Converter and at the second stage the C-Band Amplifier. Isolators have been put at each RF access. Only three DC bias are useful to supply this assembly.

This module has entirely been tested. Good performances have been achieved with a temperature compensation included in the MCM Amplifier. A gain around 42 dB (figure 12, with an 40 dB attenuation for the measurements), a noise figure less than 8 dB and an third intercept point higher than 25 dBm are carried out.

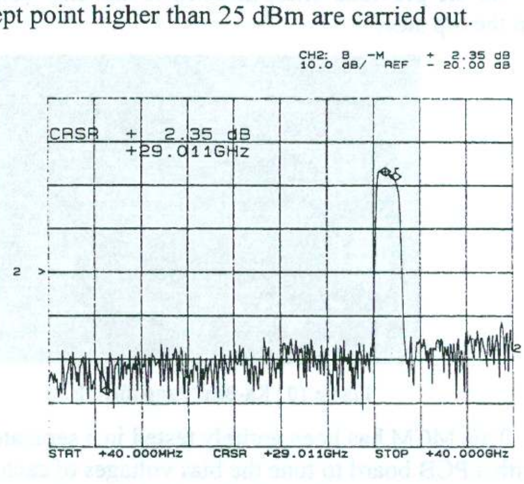

Figure 12 : Gain of the Down Converter module

B. Up Converter

It is composed of two MCMs. At the first stage, we have the Up Converter and at the second stage the Ka-Band Amplifier. Isolators have been put at each RF access. Only three DC bias are useful to supply this assembly.

This module has entirely been tested. Good performances have been carried out with a temperature compensation included in the MCM Amplifier. A gain around 25 dB (figure 13), a noise figure less than 7 dB and an third intercept point higher than 20 dBm are carried out

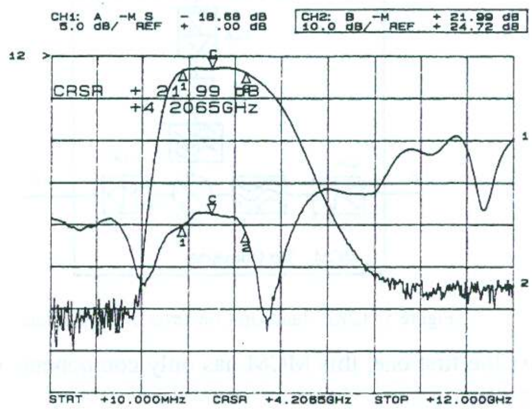

Figure 13 : Gain of the Up Converter module

VI. CONCLUSION

The new microwave MCM-C technology is going to be introduced in future space programs. It will contribute to a significant step in term of competetivity. This technology is particularly useful for the Ka-Band where its impact will be even more pronounced in view of low cost and small size equipment. Architecture of all these advanced microwave sub-assemblies have been detailed here. Each of the third MCM have been tested with success and in accordance with the specifications. The global performances are very interesting for our future products.

VII. ACKNOWLEDGMENT

The authors would like to thank Guiliano GATTI from ESA/ESTEC for his support in this study.

VIII. REFERENCES

[1] Claude DREVON, Sébastien GEORGE, Augustin COELLO VERA, Michel POUYSEGUR, Jean-Louis CAZAUX, "Mixed L.F. / R.F. MCM", *47th Electronic Components & Technology Conference*, May 1997

[2] Agnès RECLY, Hervé LEVEQUE, Jean-Louis CAZAUX, Christian TRONCHE, Paul VAN LOOCK, Ivar WANGEN, Frédéric ANDRE, Giuliano GATTI, Francesco EMMA, "MCM Building Blocks for Ka-Band Telecommunication Equipment", *ESA Workshop on Millimeter Wave Technology and Applications*, May 1998

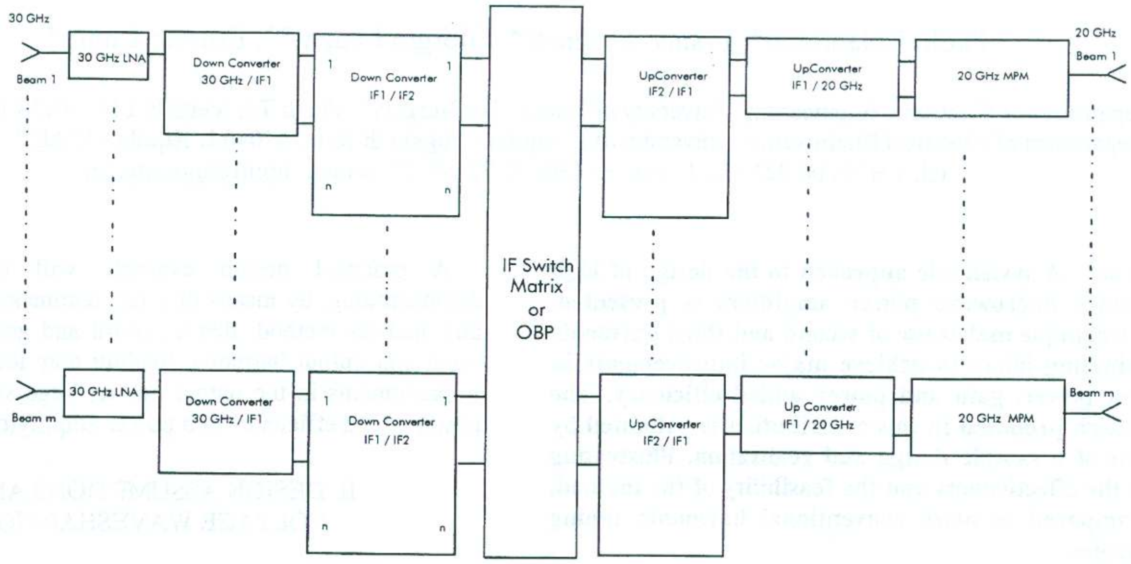

Figure 14 : Example of payload architecture